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APOLLO MISSION TECHNIQUES C-PRIME LUNAR (ALTERNATE 1) CONTINGENCY PROCEDURES (REVISION A)

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MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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December 16, 1968

APOLLO SPACECRAFT PROGRAM OFFICE
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved by Howard W. Tindall Jr.
Howard W. Tindall, Jr., Chief
Apollo Data Priority Coordination

FOREWORD

This document presents the approved guidance and control sequence of events, the data flow, and real-time decision logic for the C-prime lunar mission contingency procedures. The purpose of this document is to insure compatibility of all related MSC and supporting contractor activities.

For each mission phase, a Data Priority Working Group has been established under the direction of the Chief, Apollo Data Priority Coordination, ASPO. These groups, which are comprised of representatives of MSC and support contractors, hold frequent meetings to coordinate their various associated activities and develop agreed upon mission techniques. TRW assists in the development of the techniques and documents them for ASPO. After formal review by ASPO, E&DD, FCOD, FOD, GAEC, MDC, MIT, NR and TRW, a document such as this one is issued. This mission techniques document is one of seven documents describing the C-prime lunar mission. The others are:

- Saturn V/Apollo Launch Aborts
- Earth Parking Orbit and Translunar Injection
- Translunar Midcourse Corrections and Lunar Orbit Insertion
- Lunar Orbit Activities
- Transearth Injection, Midcourse Corrections, and entry
- Tracking Data Selection Controllers Procedures

Launch phase contingency procedures are presented in the Saturn V/Apollo Launch Aborts document (Reference 1) and so are not discussed in detail herein.

This document is the final version of the C-prime Lunar (Alternate 1) Contingency Procedures document (Revision A). The vertical bars which appear in the margins of the text and flow diagrams represent changes to the last edition of this document.

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NOMENCLATURE

ACRA	Atlantic Continuous Recovery Area
ADRA	Atlantic Discrete Recovery Area
AK	apogee kick
ASAP	as soon as practicable
BMAG	body mounted attitude gyro
CDR	Crew Commander
CLA	contingency landing area
CM	command module
CMC	Command Module Computer
CMP	Command Module Pilot
CO	cutoff
COI	contingency orbit insertion
CSM	command service module
DET	digital event timer
DSKY	CM display and keyboard
DVM	delta velocity magnitude
EDS	emergency detection system
EI	entry interface
EMS	entry monitoring system
EPO	earth parking orbit
ESS	early S-IVB staging
ET	elapsed time
FDAI	flight director attitude indicator
GDC	guidance display coupler
g. e. t.	ground elapsed time

GNCS	guidance, navigation and control system
G&N	guidance and navigation system
$\dot{h}$	rate of change in altitude (measured in feet per second)
h_a	Keplerian apogee altitude (measured in nautical miles above a spherical reference body-earth of pad radius or moon)
h_p	Keplerian perigee altitude (measured in nautical miles above a spherical reference body-earth of pad radius or moon)
IMU	inertial measuring unit
IU	Saturn launch vehicle instrument unit
KSC	Kennedy Space Center
LES	launch escape system
LM	lunar module
LO	lift-off
LOI	lunar orbit insertion
LOI_1	lunar orbit insertion into 60-by 170- nautical mile orbit maneuver
LOI_2	lunar orbit insertion, 60-nautical mile orbit circularization maneuver
LTA-B	LM mockup carried on the C-prime launch vehicle
LV	launch vehicle
MCC	midcourse correction
MCC-H	Mission Control Center - Houston (referred to in text as the ground)
MSFN	Manned Space Flight Network
PLA	planned landing area
RCS	reaction control system

REFSMMAT	transformation matrix from earth centered inertial reference to stable member inertial coordinates
RTCC	Real-Time Computer Complex (MCC-H)
RTEAP	return-to-earth abort processor
SC	spacecraft
SCS	stabilization control system
S-IC	Saturn V first stage booster
S-II	Saturn V second stage booster
S-IVB	Saturn V third stage booster
SPS	service module propulsion system
t	time reference
t_B	burn duration
TEC	transearth coast
TEI	transearth injection
TFI	time from ignition
THC	translational hand controller
TIG	time of ignition
TLC	translunar coast
TLI	translunar injection
V or V_I	inertial velocity
ΔV, ΔVM	velocity increment

1. INTRODUCTION

The C-prime lunar (alternate 1) mission profile consists of:

a) Launch and boost to EPO during a launch window ranging either from 20 to 27 December 1968 or from 18 to 24 January 1969.

- Space vehicle launch from KSC Launch Complex 39A on a variable flight azimuth of 72 to 108 degrees dependent on launch time.
- S-IVB/IU/ spacecraft (SC) inserted into a nominal 103-nautical mile circular EPO after completion of S-IC, S-II, and partial S-IVB stage burns.

b) Coast in EPO for two or three orbits during which time launch vehicle (LV) and SC systems checkout will take place.

c) Translunar injection (TLI)

- S-IVB stage restarted over the Pacific Ocean during either the second orbit (first injection opportunity) or the third orbit (second injection opportunity).
- S-IVB/IU/SC injected into a free return translunar trajectory.

d) Translunar coast (TLC)

- CSM separated from S-IVB/IU/LTA-B
- The S-IVB executes a dump of residual propellants to achieve slingshot. *
- Midcourse corrections (MCC's) are executed as required

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*The S-IVB slingshot consists of placing the S-IVB on a close approach lunar trajectory whereby the S-IVB stage is nominally transferred to a solar orbit.

e) Lunar phase

- The crew executes a retrograde SPS burn (LOI_1) into a 60- by 170-nautical mile lunar orbit.
- After two orbits, a second retrograde SPS burn (LOI_2) into a 60-nautical mile circular lunar orbit is executed.
- The CSM continues in orbit for eight orbits while the crew performs landmark sightings and photographic exercises.
- The crew then executes a posigrade SPS burn into a transearth trajectory (TEI).

f) Transearth Coast

- The crew executes MCC's as required

g) Earth Reentry

The C-prime mission is performed with the AS-503 LV and the CSM-103 SC with an LTA-B which replaces the LM during launch.

This document defines the G&N related monitoring techniques and resultant contingency procedures (excluding alternate mission possibilities*) which involve real-time decisions by the crew and ground (MCC-H) during the mission. Figure 1 presents an overall view of the C-prime lunar mission contingency procedure options. An overall contingency procedures timeline for the C-prime lunar mission is presented in Figure 2. The contingency procedure modes shown in Figure 2 read vertically down in their order of priority (i. e., the top contingency mode is the one which would be executed before considering the next lower mode, etc.). In addition, those contingency modes shown on the same level for different mission phases are assumed to be equal in likelihood of ever being required.

The monitoring techniques and contingency procedure options are presented in flow charts which depict the necessary crew and corresponding

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*Apollo 8 Spacecraft Operational Alternate Mission Plans, Volume 1, Earth Orbit Alternatives, MSC Internal Note 68-FM-280, November 21, 1968.

MCC-H G&N related real-time decisions.* The contingency procedures contained in these flow charts are based on References 1 through 7. Detailed discussion of these procedures are presented in the remaining sections (2 through 7) of this document. The TEC and earth reentry phases shown in Figure 2 are not discussed in this report. A detailed account of these is given in Reference 8.

The operational abort plan and the launch window effects on the operational abort plan are presented in References 9 and 10. Pertinent details from these documents are included in the forthcoming sections of this document.

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*A single flow chart for SPS burn monitoring is presented in Section 6 in conjunction with the discussion of LOI and TEI burn monitoring. However, this chart is generally applicable for any major SPS burn phase which includes abort burn monitoring.

2. LAUNCH PHASE CONTINGENCY PROCEDURES

Launch phase contingencies consist of launch abort, contingency orbit insertion (COI), and early S-IVB staging (ESS) maneuvers (Reference 1). The initiation of a contingency maneuver is determined from specific displays which are monitored by the ground and crew throughout the launch phase.

The launch abort modes consist of:

- Mode I aborts which utilize the launch escape system (LES) to remove the CM from the LV. These aborts are possible from just prior to lift-off (LO) until the LES is jettisoned at a nominal time of 3 minutes 7 seconds g. e. t. Mode I aborts may be initiated automatically by the emergency detection system (EDS) or manually by turning the translation hand controller (THC) counterclockwise.

- Mode II aborts which employ a full-lift entry profile into the Atlantic Continuous Recovery Area (ACRA). These aborts are nominally possible from LES jettison at 3 minutes 7 seconds g. e. t. until 10 minutes g. e. t.

- Mode III aborts which employ an SPS retro burn followed by an approximate half-lift entry profile into the Atlantic Discrete Recovery Area (ADRA). These aborts are nominally possible at any time after 10 minutes g. e. t. until EPO insertion.

The COI modes consist of:

- Mode IV which utilizes a posigrade SPS burn to achieve a safe orbit ($h_p \geq$ 75 nautical miles). This maneuver can nominally be executed at any time after 9 minutes 50 seconds g. e. t., until EPO insertion.

- Apogee Kick Mode (AK) which utilizes a posigrade SPS burn at the apogee altitude to raise the perigee altitude to 75 nautical miles. This maneuver is normally executed when the orbital perigee at S-IVB CO is favorably situated and the corresponding Mode IV ΔV requirement is greater than 100 feet per second.

The ESS maneuver consists of early staging the S-IVB stage from the S-II stage and continuing S-IVB powered flight to a safe orbit ($h_p \geq$ 75 nautical miles). The maneuver is executed in the event of S-II malfunctions which do not permit continued S-II powered flight.

The COI and ESS maneuvers are prime whenever the capability for their execution exists. When both Mode IV and AK capability overlap, the AK maneuver is prime. Figure 3 shows the overall Saturn V/Apollo launch abort flow chart concept employed in Reference 1. Contingency option decisions are obtained from the Onboard Abort* or ESS Flow Chart and/or the MCC-H Abort or ESS Request Flow Chart. Abort and COI maneuvers are initiated manually by turning the translational hand controller (THC) counterclockwise. Mode I launch aborts can also be initiated automatically by the emergency detection system (EDS). The ESS maneuver is initiated manually by depressing the S-II/S-IVB staging switch. Once an abort or COI maneuver has been initiated, the appropriate mode is determined from the Abort Mode Decision Flow Chart (Figure 3). The specific abort, COI, and ESS procedures are described in the remaining flow charts shown in Figure 3. A detailed discussion of these procedures and monitoring techniques may be found in Reference 1.

*The general term "abort(s)" as used in Reference 1 means either an abort or COI maneuver.

3. EPO CONTINGENCY PROCEDURES

EPO contingency procedures consist of monitoring critical SC systems and those LV systems required for TLI in order to determine whether or not to proceed with the TLI phase. In the event TLI is no-go, the following alternatives are available:

- Execution of potential alternate missions
- Premature earth reentry at some time during EPO. Depending on the time criticality of the malfunction which precludes TLI, the reentry could be required immediately or within a time frame sufficient to land in a planned recovery area (PLA). Detailed retrofire and reentry procedures are presented in Reference 11 for the C-prime (earth orbit) D, F, and G missions. These procedures are equally applicable for a C-prime EPO reentry maneuver. In the event of a critical SPS failure or unusable SPS propulsion system, the RCS propulsion system can be employed as a backup deorbit technique.

4. TLI (THROUGH TLI PLUS 25 MINUTES) CONTINGENCY PROCEDURES

The TLI burn is initiated at some time during either the second or third EPO revolution. The nominal TLI burn lasts for approximately 315 seconds.* The TLI contingency procedures consist of (1) TLI burn and 25-minute postburn monitoring and (2) procedures for the 90-minute abort mode, the 4-hour (no voice) abort mode, and the TLI 10-minute abort mode.

TLI burn monitoring procedures are presented in Figure 4. These procedures define primary and backup monitoring techniques and the limits which lead to a manual S-IVB shutdown. Table 1 presents a typical TLI message pad on which the ignition attitude and velocity cutoff data are recorded by the crew during EPO. The crew is also provided with TLI burn monitoring crew charts (Figures 5, 6, and 7) which consist of pad reference nominal and 45 degree dispersed pitch and yaw gimbal angles. Figure 4 was obtained from Reference 2 and modified to include S-IVB shutdown paths to alternate mission and abort situations. More detailed discussions of the monitoring techniques may be obtained from References 2 and 4. Post TLI burn monitoring consists of monitoring critical CSM and communication systems. The possible aborts which arise from TLI and post TLI (through TLI plus 25 minutes) monitoring are:

- 90-minute block data aborts which occur at TLI plus 90 minutes
- 10-minute crew chart aborts which can occur at any time during the TLI burn
- 4-hour (no voice) block data aborts which are decided during the 25-minute post TLI monitoring period and executed at TLI plus 4 hours.

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*Based on 72 degree azimuth, first opportunity launch on December 21, 1968.

The 90-minute abort mode is an RTCC or block data abort which can arise only from critical SC malfunctions which occur during the TLI burn or during the 25-minute coast period immediately following TLI that do not require an immediate earth return. This abort mode is designed to land the CSM at a contingency landing area (CLA). A go/no-go decision is made at TLI plus 25-minutes which determines whether or not the 90-minute abort will be executed. The abort is manually initiated by turning the THC counter-clockwise at TLI plus 25 minutes. This initiates the following sequence:

DET (hr:min:sec)	Event
00:00:00	S-IVB burn time is recorded; THC is turned counterclockwise initiating S-IVB shutdown. Inertial velocity (V_I) is recorded from the DSKY. The four +X RCS jets are turned on.
00:00:03	CSM/S-IVB separation occurs.
00:00:13	The four +X RCS jets are turned off, and the crew begins pitching up ($+X_b$ down) to -r (down the radius vector) using the earth as the visual reference to determine -r.
00:01:00	The four -X RCS jets are turned on to initiate an evasive maneuver to provide clearance between the CSM and S-IVB for the abort maneuver.
00:01:08	The four -X RCS jets are turned off and the crew begins maneuvering to abort maneuver thrusting attitude.
01:05:00	SPS ignition (fixed inertial attitude retro burn)

The SPS ΔV requirement is obtained from onboard block data. Detailed crew and MCC-H procedures are presented in Figure 8.

The 10-minute abort is designed to effect the fastest possible return to earth and is executed only in the event of a critical CSM malfunction or failure during the TLI burn which requires an immediate CSM return to earth. This abort mode does not necessarily provide a water landing. Like the launch phase and 90-minute aborts, this abort mode is manually initiated by turning the THC counterclockwise. On initiation the following sequence of events takes place.

Time from S-IVB Cutoff (min:sec) g.e.t.	Event
00:00	S-IVB burn time is recorded; THC is turned counterclockwise initiating S-IVB shutdown. Inertial velocity (V_I) is recorded from the DSKY. The four +X RCS jets are turned on.
00:03	CSM/S-IVB separation occurs.
00:13	The four +X RCS jets are turned off, and the crew begins pitching up ($+X_b$ down) to -r (down the radius vector) using the earth as the visual reference to determine -r.
01:00	The four -X RCS jets are turned on to initiate an evasive maneuver to provide clearance between the CSM and S-IVB for the abort maneuver.
01:08	The four -X RCS jets are turned off, the crew begins maneuvering to abort maneuver thrusting attitude (Figure 9) driving to the following IMU gimbal angles initially: OGA = 180 deg MGA = 0.0 deg IGA = ground computed prior to lift-off.
04:00	The crew selects the abort ΔV from a chart of ΔV versus V_I and S-IVB t_B (Figure 9) and enters this value in the ΔV counter. The crew begins preparations for an SCS automatic maneuver.

Time from S-IVB Cutoff (min:sec) g.e.t.	Event
05:00	The COAS elevation angle is reset to 0 deg CDR pilot adjusts his position in the couch to view the horizon through the COAS reticle image.
09:30	The spacecraft is aligned to the required horizon referenced attitude (Figure 9).
10:00	The SPS is ignited and the burn is controlled by SCS automatic.

The SPS burn attitude, SPS ΔV requirement, and time to entry interface are determined as functions of the inertial velocity at S-IVB CO from onboard crew charts (Figures 9 and 10). A detailed abort procedures flow chart is presented in Figure 11.

In the event that voice communications are lost at TLI plus 25 minutes, the crew will stand by to execute a block data 4-hour TLC abort maneuver. This maneuver provides an early earth return to a contingency recovery area (CLA) and employs the nominal CSM separation sequence.* Block data for both the 90-minute and 4-hour abort modes are passed to the crew during EPO. If possible (communications exist), these block data are updated at TLI plus 60 minutes. The block data messages are sent in accordance with the abort maneuver update pad format presented in Table 2. Detailed 4-hour (no voice) abort procedures are presented in Figure 8 along with the 90-minute abort procedures.

*For navigation purposes and subsequent entry corridor control, a minimum of 40 hours of coast time is recommended for all cislunar abort trajectories, Reference 12.

5. TLC CONTINGENCY PROCEDURES

TLC contingency procedures become applicable at any time after the block-data point at TLI plus 90-minutes and prior to initiation of the LOI_1 maneuver. These maneuvers are all designed to return to a CLA. The monitoring consists of checking time-critical system parameters and voice communication failure indicators. The contingency options consist of a quick return TLC abort maneuver, a lunar flyby abort maneuver, and alternate mission plans which preclude continuing the nominal mission. A voice communication failure in conjunction with a time-critical CSM system malfunction constitutes grounds for a quick return abort at the next block-data opportunity. If a minimum return time is not required and voice communications are lost, a lunar flyby block data (LOI minus 8 hours) abort will be executed provided the block data has been received. The lunar flyby maneuver will always be executed at LOI minus 8 hours. It will be targeted to raise pericynthian to between 200 and 1500 nautical miles and to result in a CLA landing (Reference 13). The block-data abort opportunities occur at approximately 4, 11, 25, 35, 44, 59, (LOI minus 8 hours) and 68 (pericynthian plus 2 hours) hour times after TLI. Block data solutions are passed from MCC-H to the crew, two quick return solutions in advance assuming execution of estimated MCC's. Starting at TLI plus 9 hours, the first lunar flyby abort solution (LOI minus 8 hours) is passed to the crew. This solution is updated at every block data update opportunity thereafter if required. The block data message times and corresponding abort maneuver times are presented in Table 3. The last message also includes premature TEI block data

Detailed TLC abort procedures are presented in the TLC Abort Flow Chart (Figure 12). The chart assumes that either a time-critical CSM system malfunction or voice communications failure has occurred and that a TLC abort must be performed. In the no-voice case, the crew procedures are designed for maximum use on onboard systems. In the case where voice communications exist the ground is prime for determining an external ΔV abort solution which is voiced to the crew for execution at the specified SPS ignition time.

6. LOI CONTINGENCY PROCEDURES

The lunar phase activity nominally begins with initiation of the LOI_1 burn into a 60- by 170-nautical mile orbit. After two revolutions an LOI_2 burn into a 60-nautical mile circular orbit is executed. The nominal mission plan calls for eight revolutions in the 60-nautical mile orbit after which a TEI burn is performed which injects the CSM into a transearth trajectory. LOI phase contingencies determined from SPS burn monitoring consist of alternate missions and LOI Mode I and Mode III aborts.

An SPS burn monitoring flow chart is presented in Figure 13. This chart defines the crew and ground real-time decision logic for use of backup monitoring and/or G&N systems and manual SPS shutdown logic. The attitude/rate monitoring and SPS shutdown monitoring portions were obtained from Reference 5, where a complete discussion of the rationale involved is given. The SPS systems monitoring portion was generated herein to indicate the means by which LOI aborts (and TEI aborts discussed in Section 7) occur. As stated in Section 1, the chart is applicable for all major SPS burns, including the various SPS abort maneuvers which might occur after TLI ignition. Backup attitude references, horizon or starfield for maneuver monitoring, have been examined in Reference 14.

The possible LOI alternate missions arise from premature LOI_1 burn shutdown situations. These alternate missions consist of restarting the SPS at orbital perilune and performing a circularization burn under the following conditions:

- SPS systems have not in any way malfunctioned.
- The LOI shutdown orbit falls within an orbital boundary of 40 by 6,700 nautical miles.

In the event that either of the above conditions is not satisfied, a direct abort maneuver is executed.*

Unlike TLC aborts, LOI aborts are executed only in the event of critical SPS systems malfunctions or failures which require a premature

*If the initial h_p is less than 40 nautical miles, the abort maneuver will be preceded by an SPS burn to raise the h_p altitude above 40 nautical miles.

termination of the mission. The LOI Mode I 15-minute abort is the primary abort mode during LOI_1 and is initiated by a manual LOI_1 burn CO.* The CSM is maneuvered to the SPS abort burn attitude and at SPS CO plus 15 minutes the SPS is reignited. The SPS ΔV requirement is determined from an onboard crew chart which is presented in Figure 14 and 15. In the event it is not possible for the crew to ignite the SPS by LOI_1 CO plus 15 minutes, the crew has the following backup abort capability:

LOI_1 ΔV Magnitude DVM (fps)**	Backup LOI Abort Mode
0 to 880 (hyberbolic lunar trajectory - approximately 0 to 80 sec burn time)	Coast out of the lunar sphere influence and execute a P37 return to earth maneuver
880 to 1350 (unstable lunar orbit - approximately 80 sec to 120 sec burn time)	Coast for 5 hr and execute Mode I 5-hr abort maneuver (posigrade burn out of the lunar sphere of influence)
1350 to 3000 (stable lunar orbit-approximately 120 sec to 246 sec burn time)	Mode III abort after one orbital revolution (posigrade burn out of lunar orbit into a hyperbolic lunar departure trajectory)

In all backup abort situations the crew will use RTCC solutions from MCC-H provided communications exist. In the event of a communications failure or blackout, the onboard crew charts will be used. In situations when the SPS has shut down prematurely of its own accord, the 15-minute abort mode will not be used.

*The SPS systems malfunction limits (pressure and temperature) for a manual shutdown generally require an abort which is executed as soon as possible. The reason is that the limits are based on an immediately continued burn allowance sufficient for such an abort. These limits are be specified in the C-prime mission rules.

**DVM values are based on a December 21, 1968, launch.

The LOI Abort Flow Chart (Figure 16) describes abort procedures for each LOI mode. This chart assumes the GNCS to be operational throughout: the backup procedures for a nonoperational GNCS are identical to those shown in the previous TLI and TLC abort flow charts (Figures 8, 11, and 12). Typical crew chart data for the Mode I 15-minute abort, Mode I 5-hour abort, and Mode III abort are provided in Figures 14 and 15. The 15-minute abort data will be updated during TLC, to account for lunar trajectory insertion deviations determined from MSFN tracking or onboard montoring.

The Mode III LOI abort capability continues throughout the 60- by 170-nautical mile orbit phase, and the 60-nautical mile circular orbit phase. Block data abort solutions for aborts out of lunar orbit (premature TEI burn) are passed to the crew at block data g. e. t. times of approximately 76, 78, 80, 82, 84, and 86 hours. As in the case of TLC block data, abort solutions are passed two orbits at a time updating the upcoming solution as required. The crew uses the abort message pad shown in Table 2 to record the block data solutions.

7. TEI CONTINGENCY PROCEDURES

The TEI maneuver is a critical SPS burn in that it is mandatory for earth return. Therefore, the burn will be completed without shutdown if at all possible. However, TEI contingency procedures are provided for the unlikely occurance of either (1) an inadvertant SPS shutdown or (2) an extremely critical situation which crew discretion dictates a manual SPS shutdown.

The TEI contingency procedures consist of either an RTCC computed SPS abort maneuver or, in a no voice situation after achieving a hyperbolic lunar trajectory, a P37 return to earth maneuver after leaving the lunar sphere of influence. The RTCC solutions are analogous to the RTCC computed LOI abort solutions. Detailed TEI contingency procedures are presented in the TEI Abort Flow Chart (Figure 17). This chart, like the LOI Abort Flow Chart, assumes the GNCS to be operational throughout. Crew chart abort data is not provided for the TEI maneuver in that the TEI maneuver will normally be continued ASAP even in the event of a manual SPS shutdown.

Like LOI, TEI occurs behind the moon and so the monitoring procedures and techniques are essentially the same for both maneuvers. The basic difference is that an SPS shutdown during the TEI burn would be restarted within about 30 seconds for continuation of the maneuver whereas an SPS shutdown during the LOI burn would be grounds for an abort. A manual backup to the GNCS TEI cutoff will be performed by the crew at two seconds after the nominal cutoff time provided the desired cutoff velocity is confirmed by the EMS ΔV counter (ΔVCO plus 40 feet per second). Like other major SPS burns, the SPS burn monitoring procedures shown in Figure 13 are used for TEI burns.

Table 1. Typical TLI Message Pad

						TLI						
X						X						TB6p
X	X	X				X	X	X				R
X	X	X				X	X	X				P
X	X	X				X	X	X				Y
X	X	X				X	X	X				BT
												ΔVC'
+						+						VI
X	X	X				X	X	X				R SEP
X	X	X				X	X	X				P SEP
X	X	X				X	X	X				Y SEP

Table 1 Notes

- $TB6_p$ is the predicted time the SII Second Plane Separation Light will go out (TB6 + 37 seconds) (MSFC provides data)
- R, P, Y are the predicted spacecraft IMU gimbal angles at TLI ignition (deg).
- BT is the predicted duration of the TLI burn. (MSFC provides data)
- ΔVC' is the value set into the EMS ΔV counter which includes predicted longitudinal ΔV plus tailoff (fps). (MSFC provides data)
- VI is the predicted inertial velocity the DSKY should display after TLI cutoff (fps) (includes S-IVB tailoff) (MSFC provides data)
- R, P, Y SEP are the predicted spacecraft IMU gimbal angles at the post-TLI separation attitude (S-IVB cutoff + 15 minutes).

Table 2. Typical Abort Maneuver Message Pad

COMMENTS

^{R}ALIGN ______ ______ ______

^{P}ALIGN ______ ______ ______

^{Y}ALIGN ______ ______ ______

ULLAGE ____________________

____

____

____

HORIZON/WINDOW ______

____

____

____

OTHER ____________________

____

____

____

MANEUVER						
						PURPOSE
		/				PROP/GUID
+						WT N47
	0	0				P_{TRIM} N48
	0	0				Y_{TRIM}
+	0	0				HRS GETI
+	0	0	0			MIN N33
+	0					SEC
						ΔV_X N81
						ΔV_Y
						ΔV_Z
X	X	X				R
X	X	X				P
X	X	X				Y
+						H_A N44
						H_P
+						ΔVT
X	X	X				BT
X						ΔVC
X	X	X	X			SXTS
+					0	SFT
+				0	0	TRN
X	X	X				BSS
X	X					SPA
X	X	X				SXP
	0					LAT N61
						LONG
+						RTGO
+						VIO EMS
						GET .05G

Table 2. Notes

- PURPOSE is the name of the maneuver (e. g., 90-minute or 4-hour abort)
- PROP/GUID is propulsion and guidance selected (SPS/P30)
- WT is the CSM weight (lb)
- P_{TRIM} and Y_{TRIM} are respectively the pitch and yaw trim SPS gimbal angles (deg)
- GETI is the time of ignition
- ΔV_x, ΔV_y, ΔV_z are the P30 velocity to be gained components in local vertical coordinates (fps)
- R, P, Y are the IMU gimbal angles at the time of ignition for the abort maneuver (deg)
- H_A, H_P are the altitude of apogee and perigee, respectively above launch pad radius (n mi)
- ΔVT is the total inertial velocity impulse (fps)
- BT is the burn time (min:sec)
- ΔVC is the EMS ΔV counter input
- SXTS is the sextant star to be used for the abort ignition attitude check
- SFT is the sextant shaft angle for the SXTS (deg)
- TRN is the sextant trunnion angle for the SXTS (deg)
- BSS is the boresight star for an ignition attitude check using the COAS (as required)
- SPS is the BSS pitch angle (COAS) (as required) (deg)
- SXP is the BSS X position (COAS) (as required) (deg)
- LAT and LONG are, respectively, the latitude and longitude of the resultant landing point following the abort maneuver (deg)
- RTGO is the range to go for the entry maneuver (EMS) (n mi)
- VIO is the EMS inertial velocity for the entry maneuver (fps)
- GET .05 g is the estimated ground elapsed time to the 0.05 g level of acceleration for the entry maneuver (hr:min:sec)

Table 3. Typical Block Data Update and Corresponding TLC Abort Times

Update times (g. e. t.) (hr from LO)	Updated abort maneuver times related below are for times after TLI (g. e. t. ≈ 3 hr)
5	4-hr (update) and 11-hr TLC
12	11 (update), 25-hr, and LOI -8 hr* TLC
25	25 (update), 44-hr, and LOI -8 hr* (update)
35	35-hr (update), 44-hr, and LOI -8 hr* (update)
44	44 (update), LOI -8 hr* (update) and hp +2 hr early return**
51	LOI -8 hr* (update) hp +2 hr early return** (update)
66	hp +2 hr early return** (update) and TEI_1, and TEI_2 premature returns***

*Occurs at g. e. t. of approximately 59 hours

**Occurs at g. e. t. of approximately 71 hours 15 minutes

***TEI_1 and TEI_2 are premature TEI burns which can be executed after each of the two orbits prior to the LOI_2 burn.

MISSION PHASE	CONTINGENCY PROCEDURE OPTIONS
LAUNCH PHASE	• ESS • COI • LAUNCH ABORT
EPO PHASE	• ALTERNATE MISSION • PREMATURE REENTRY
TLI PHASE (UNTIL TLI + 25 MIN)	• ALTERNATE MISSION • 90-MIN OR 4-HR TLC ABORT • 10-MIN ABORT
TLC PHASE	• ALTERNATE MISSION • TLC ABORT
LUNAR PHASE	• ALTERNATE MISSION • PREMATURE TEI • MODE I LOI ABORT • MODE III LOI ABORT
TEI PHASE	• MODE III TEI ABORT • MODE I TEI ABORT

Figure 1. Overall C-prime Lunar Contingency Procedure Options

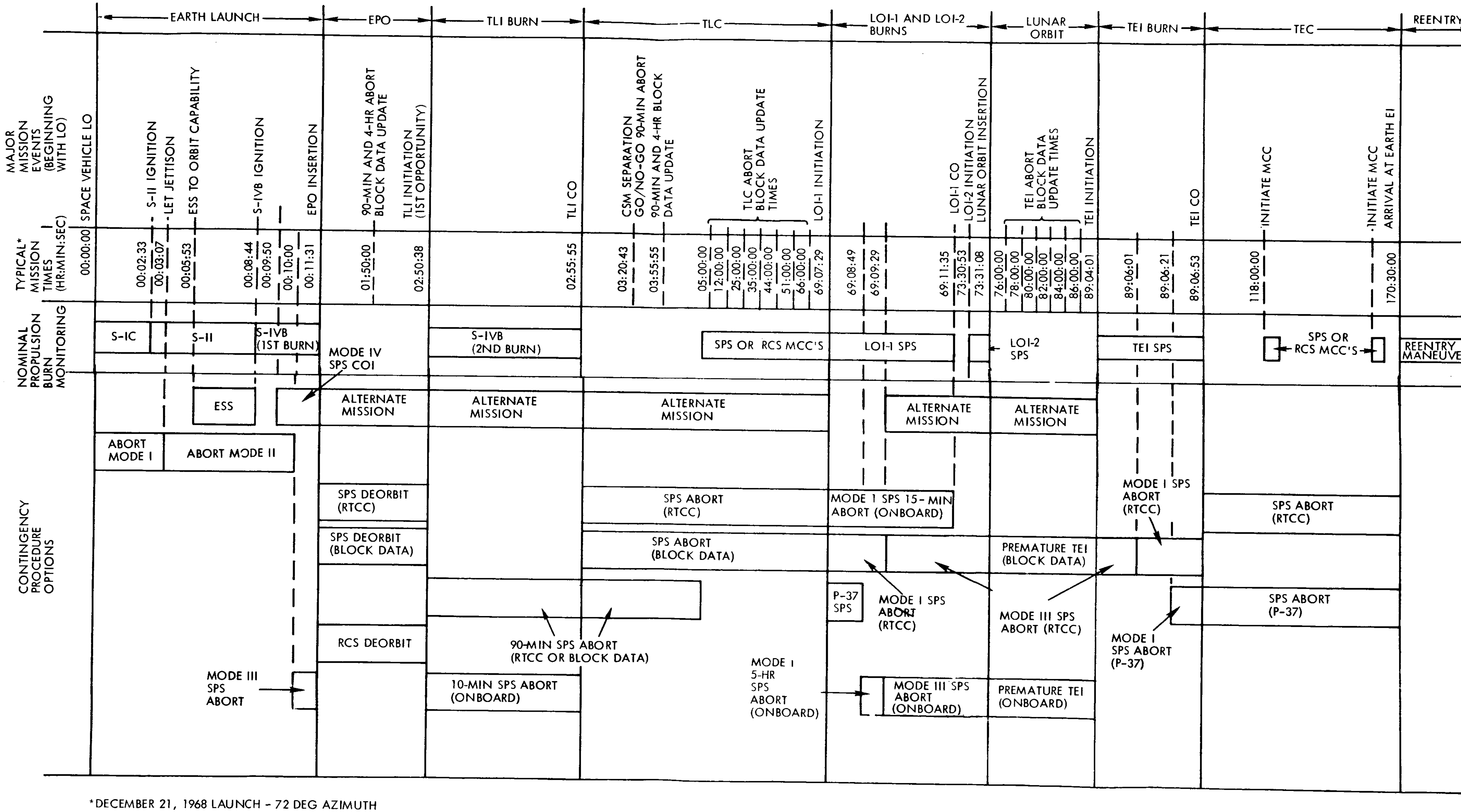


Figure 2. Overall C-prime Lunar Contingency Procedures Timeline

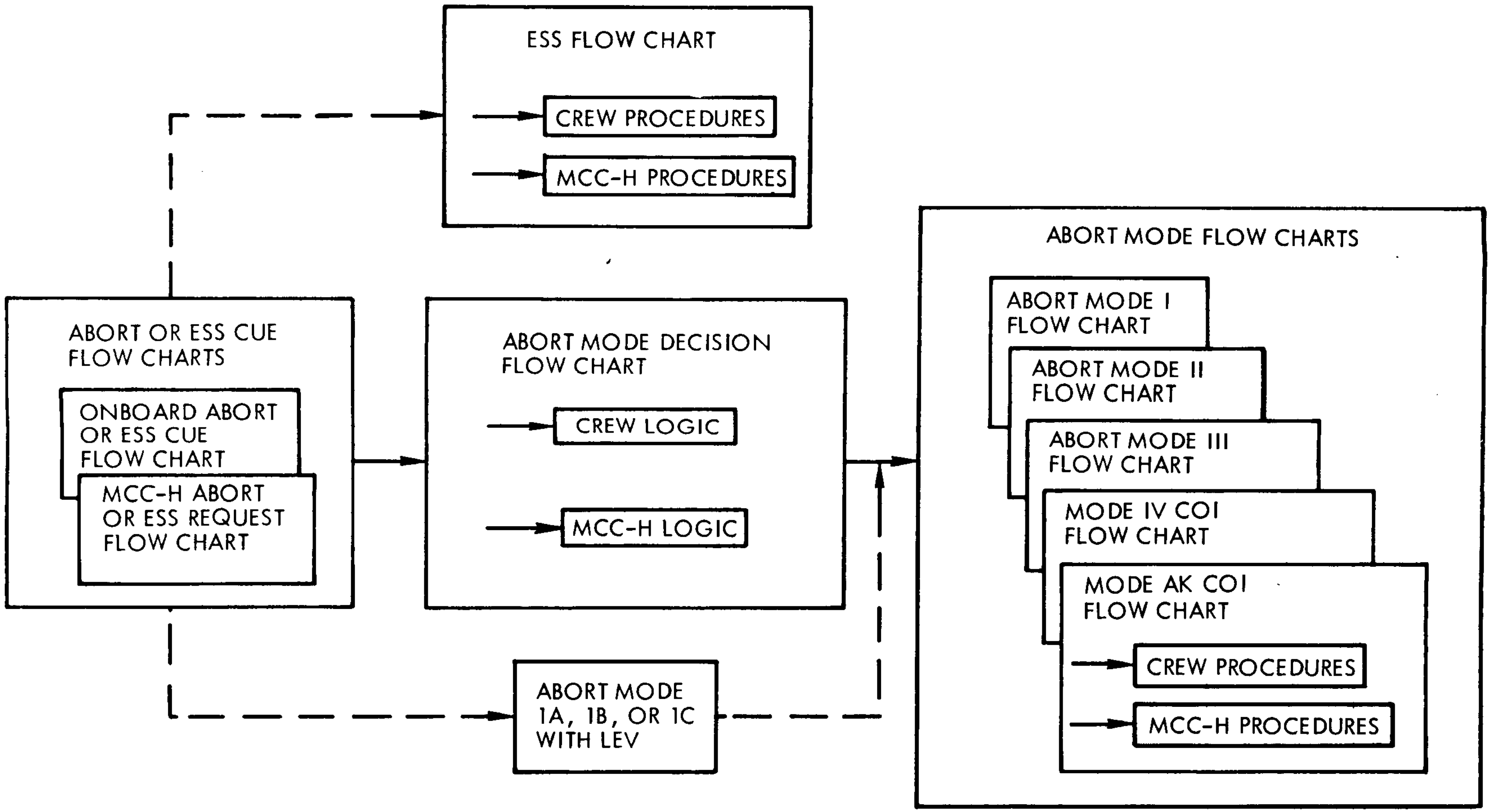


Figure 3. Overall Saturn V/Apollo Launch Abort Flow Chart Concept

TLI BURN MONITOR

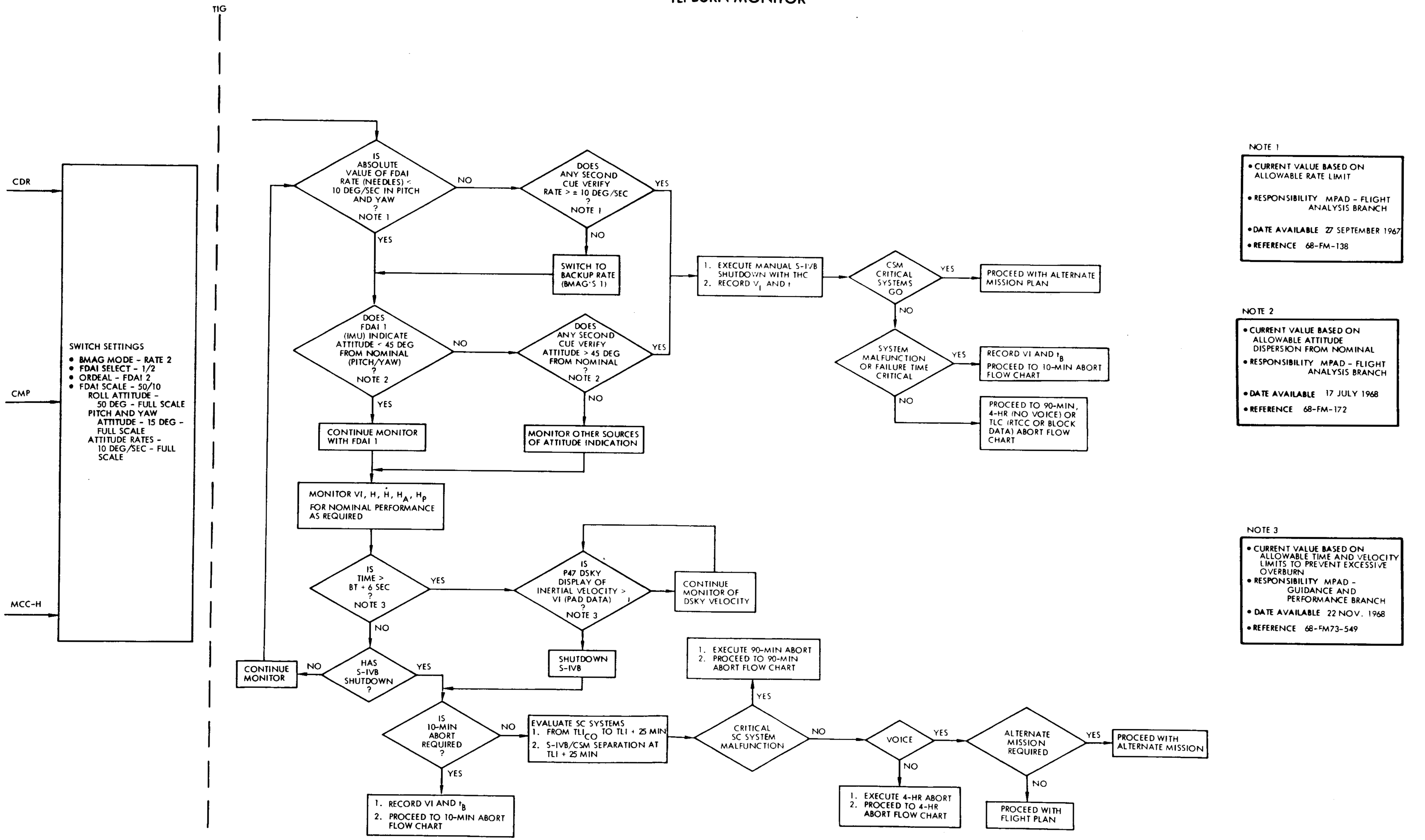


Figure 4. TLI Burn Monitor Flow Chart

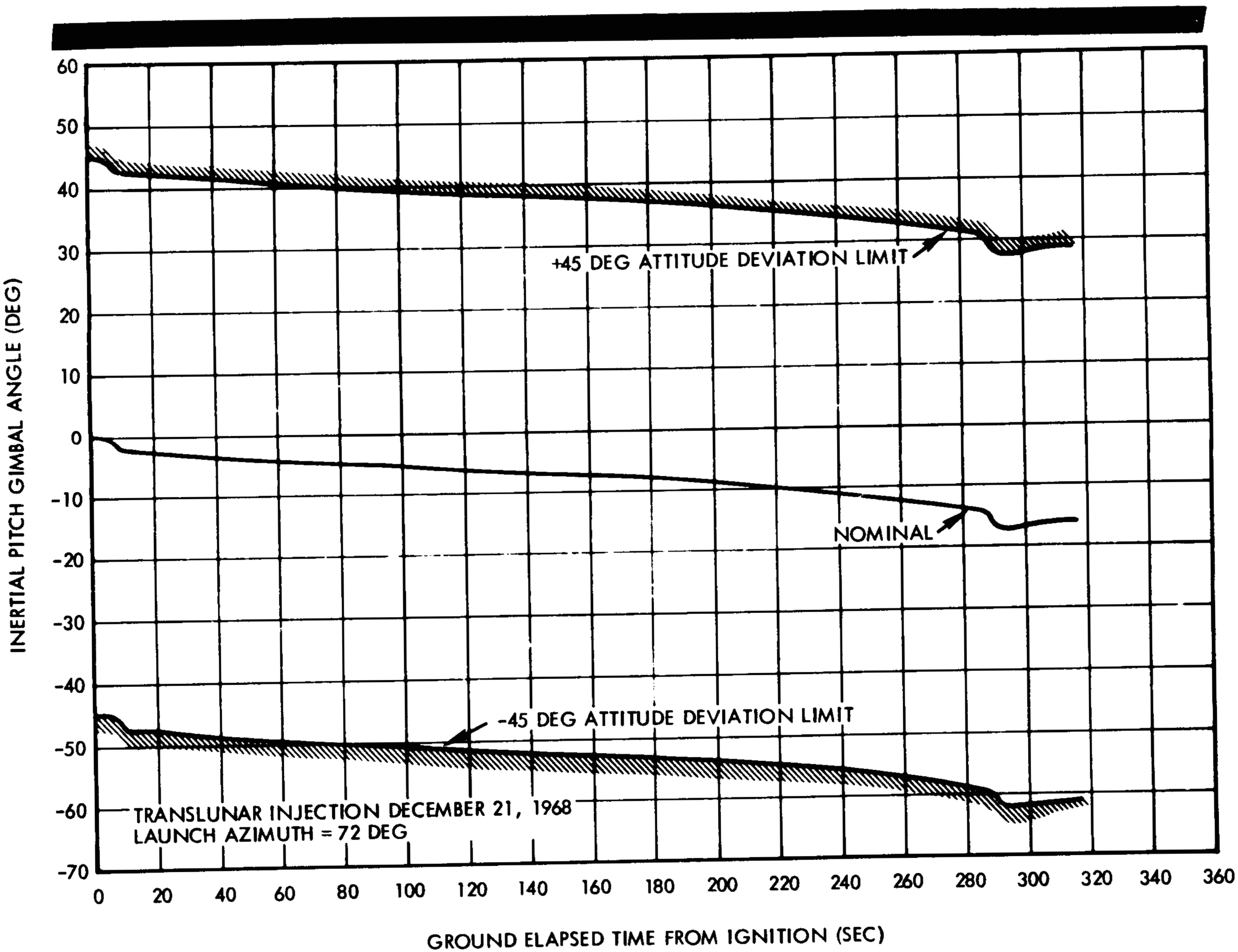


Figure 5. Typical TLI Burn Monitoring Pitch Gimbal Angle Crew Chart

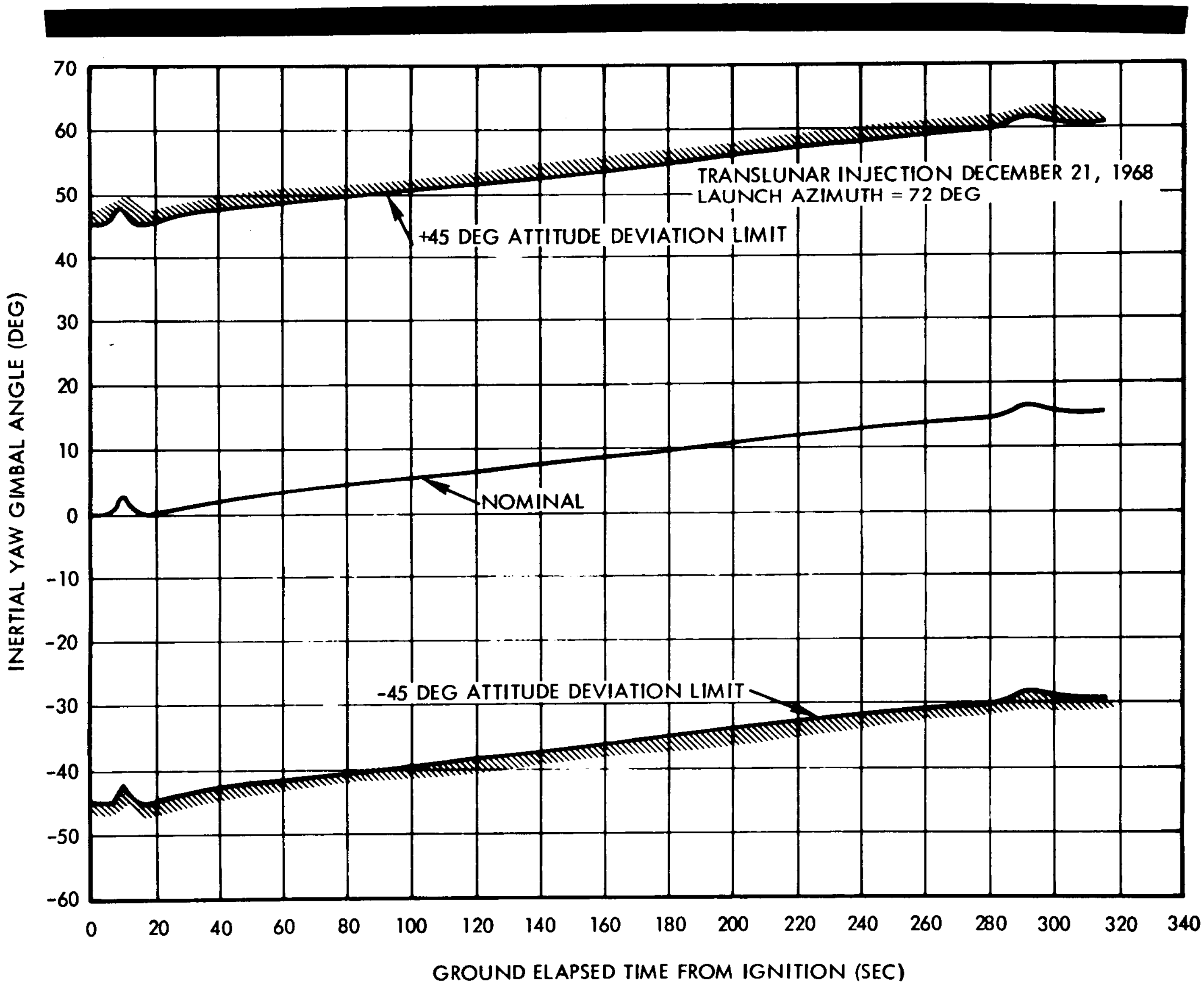


Figure 6. Typical TLI Burn Monitoring First Opportunity Yaw Gimbal Angle Crew Chart

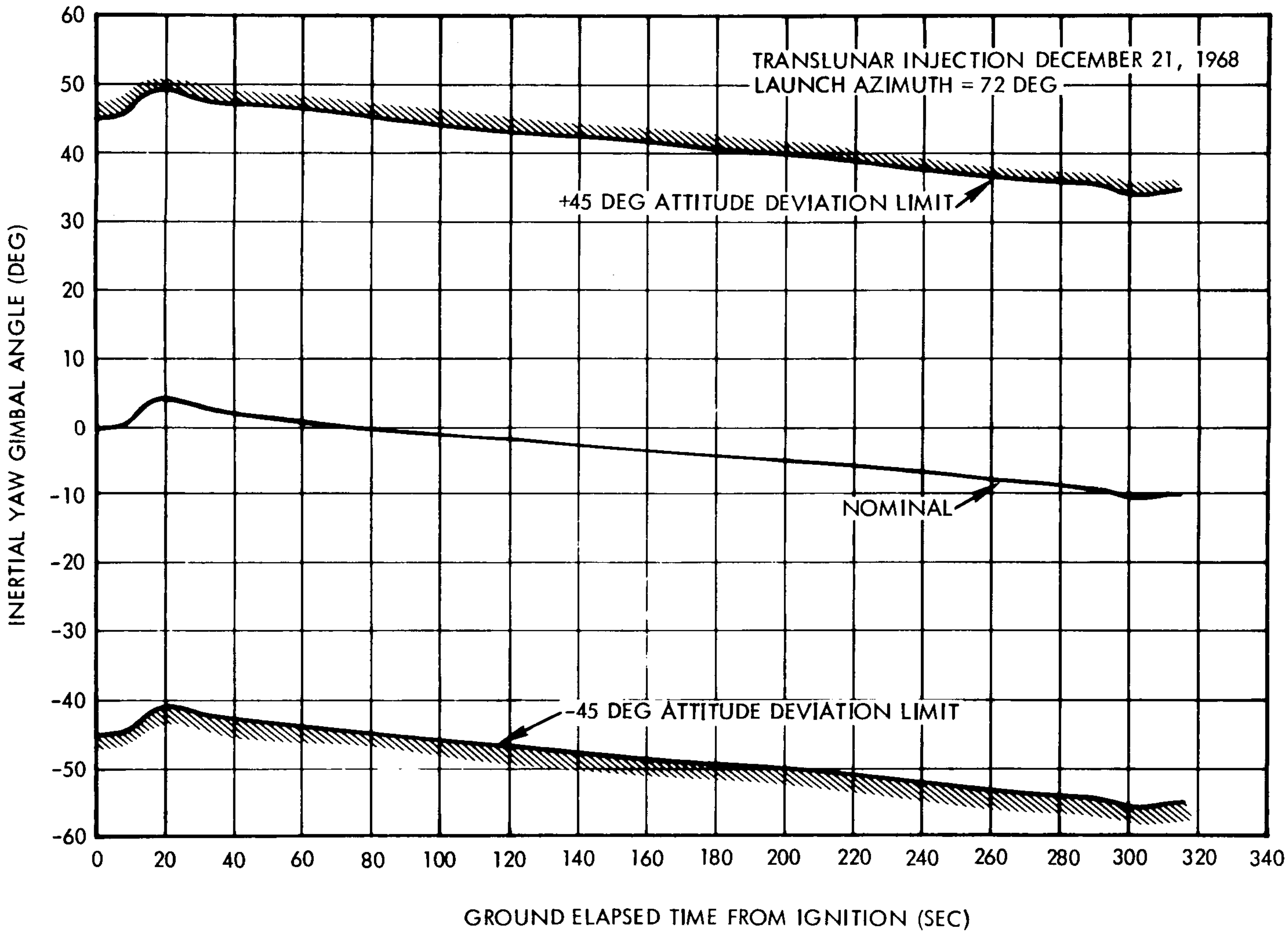


Figure 7. Typical TLI Burn Monitoring Second Opportunity Yaw Gimbal Angle Crew Chart

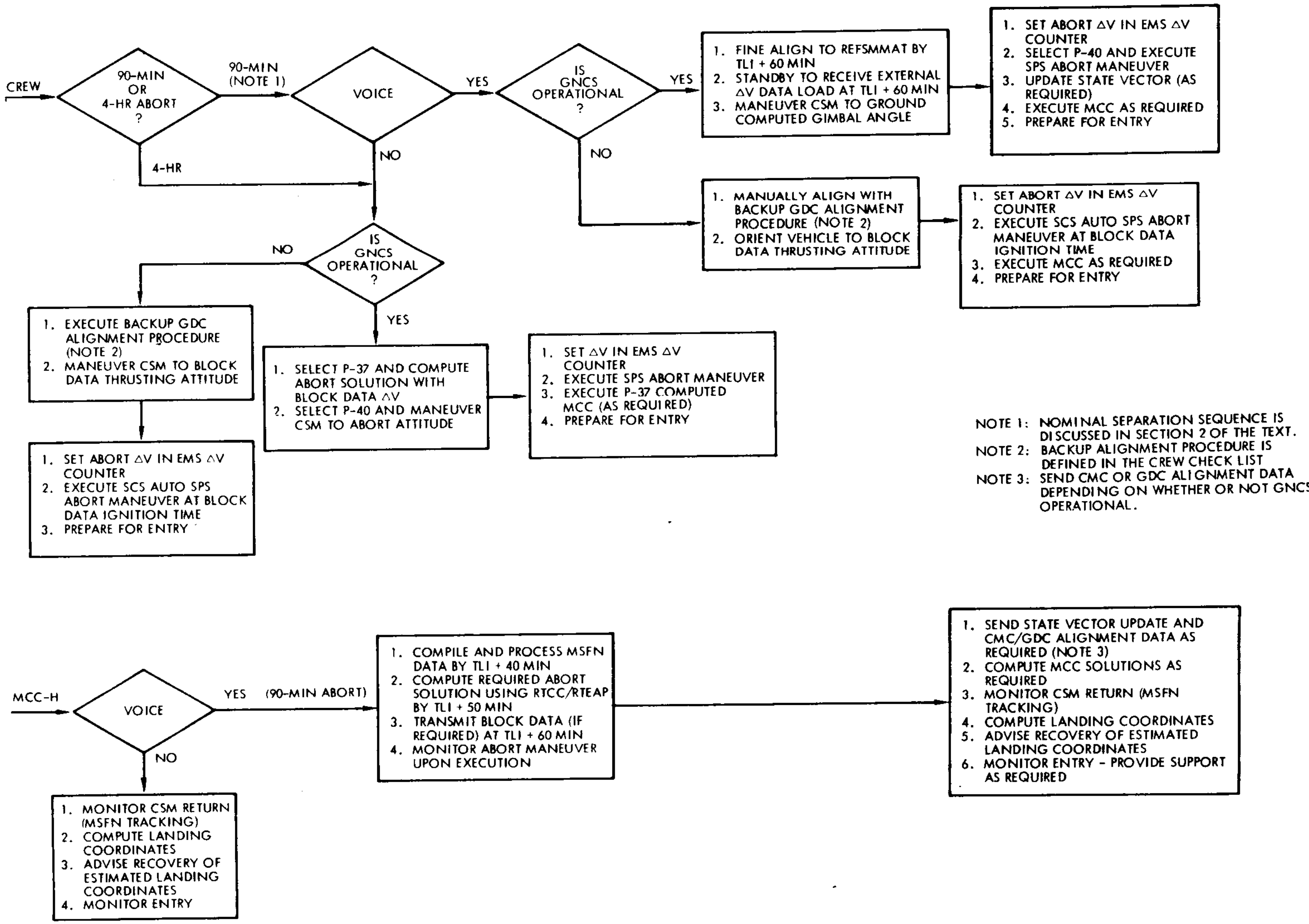


Figure 8. 90-Minute and 4-Hour (No Voice) Abort Flow Chart

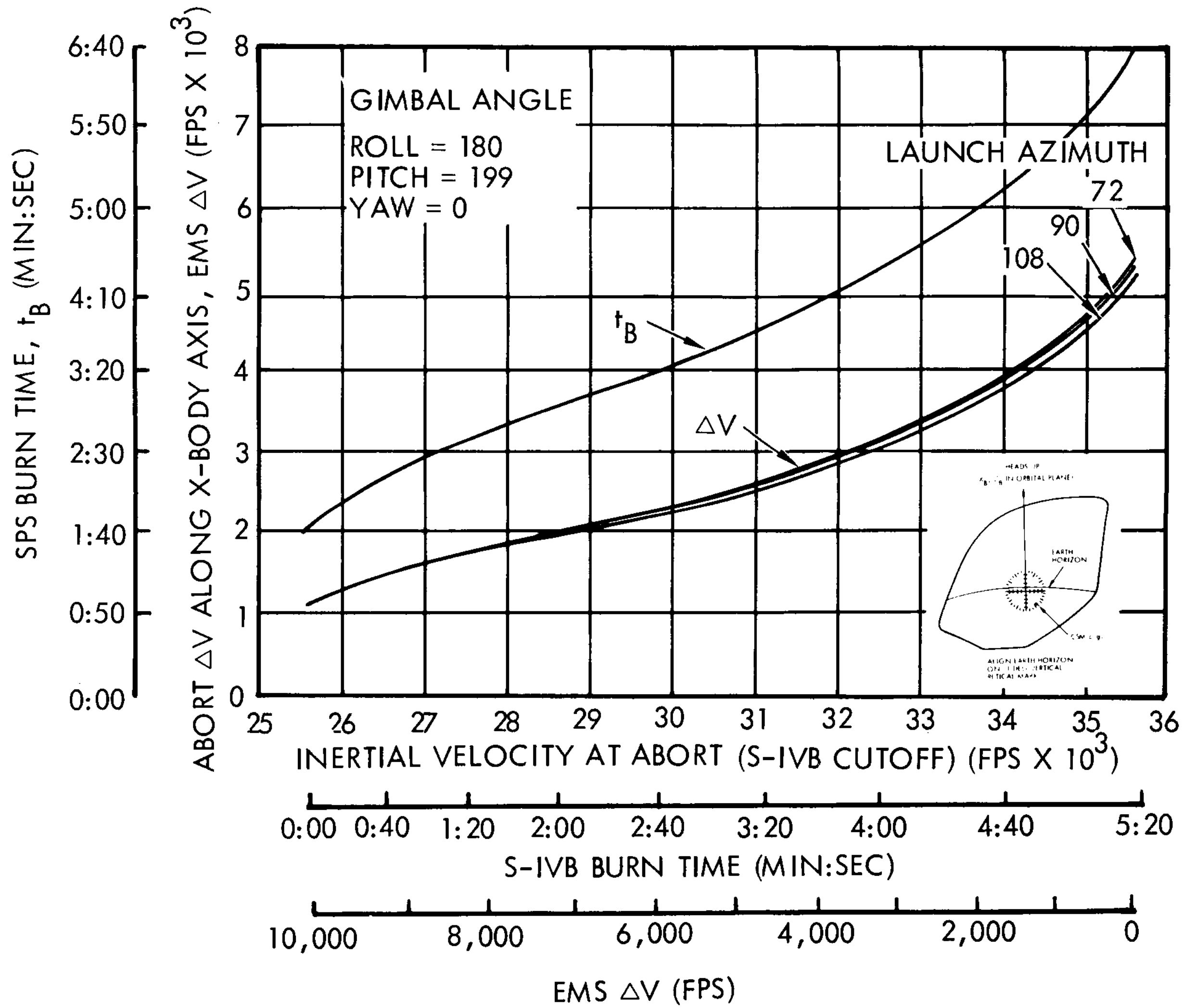


Figure 9. 10-Minute Abort ΔV Burn Time and Burn Attitude Crew Chart

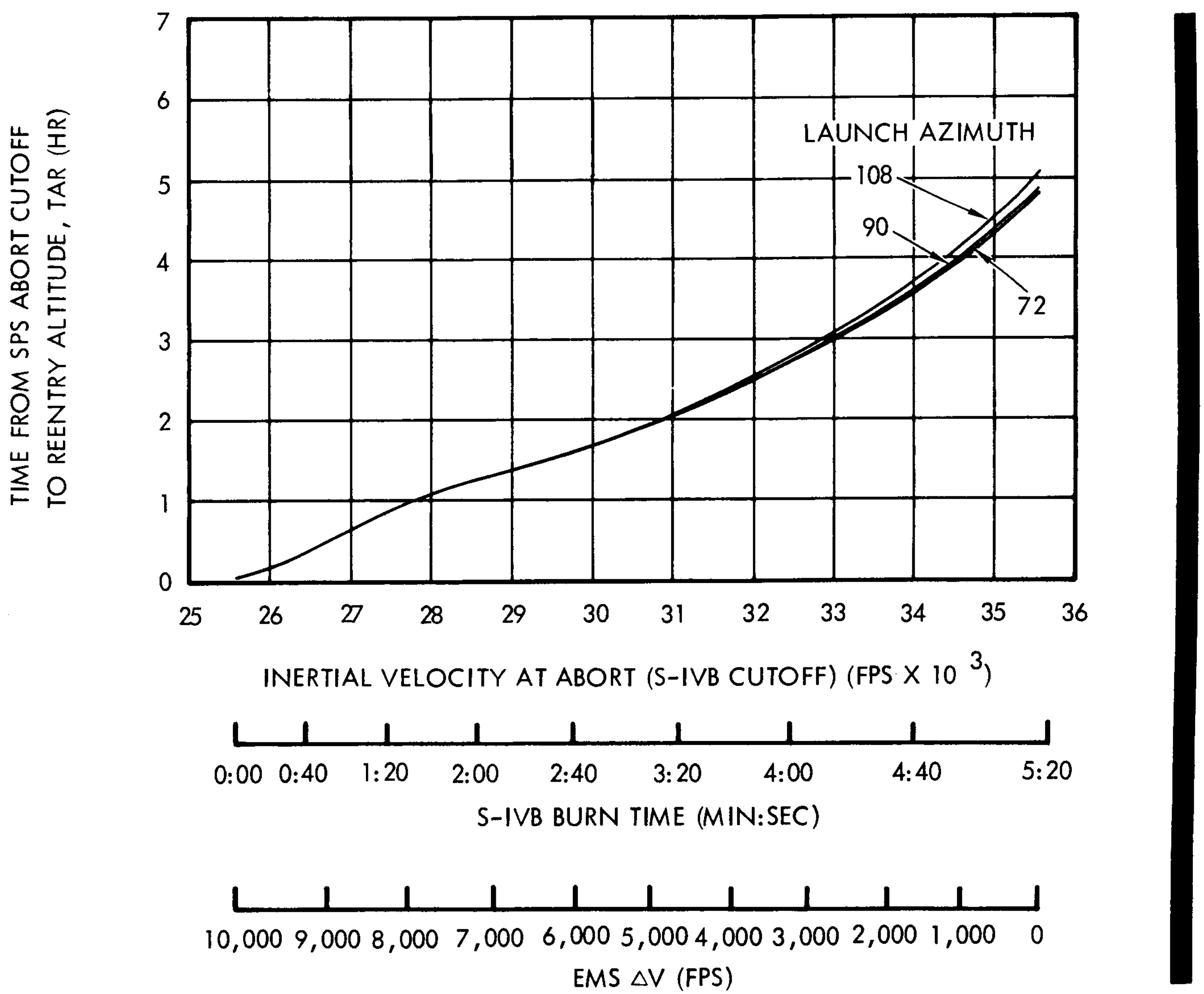
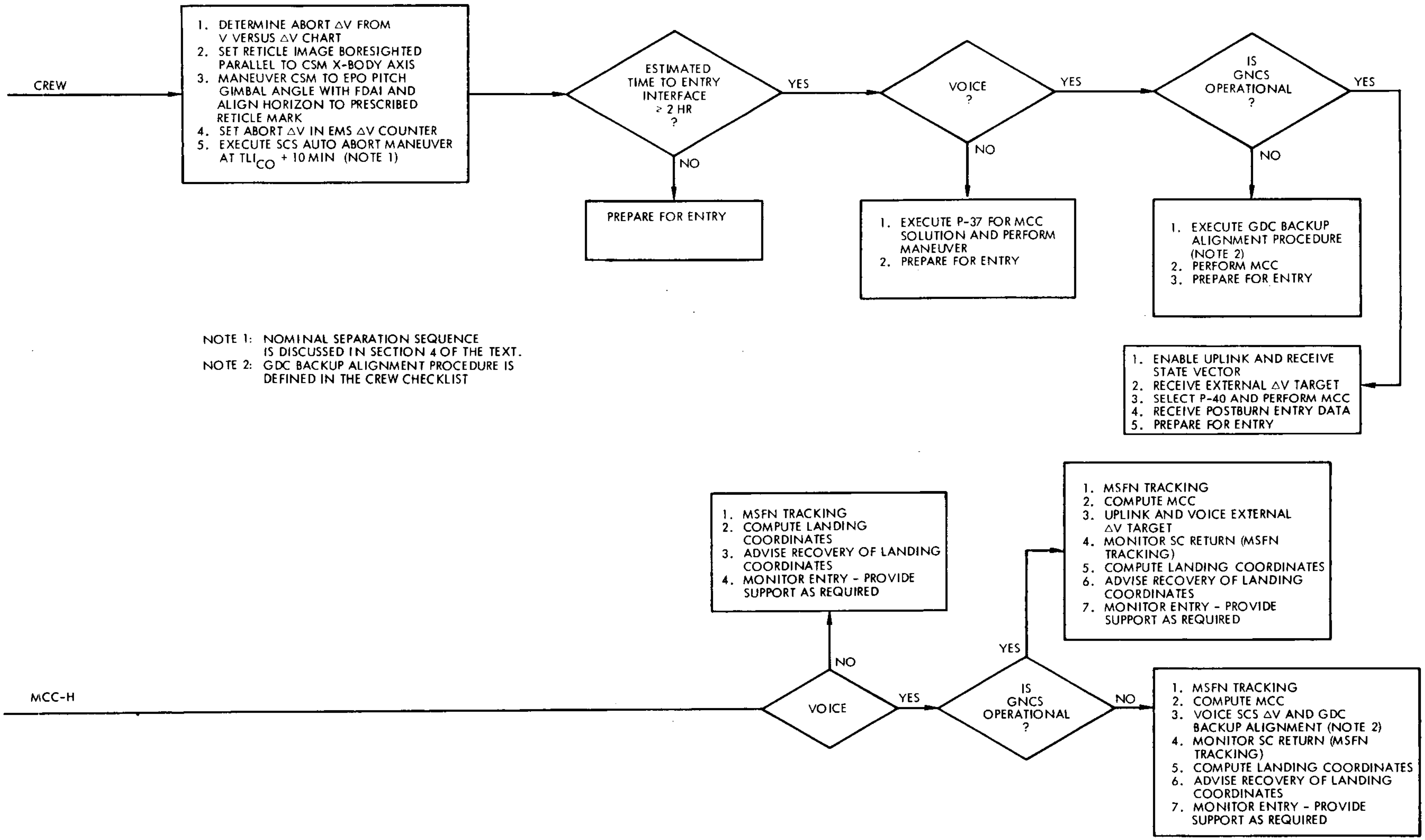


Figure 10. 10-Minute Abort Time from SPS Abort Cutoff to Reentry Altitude Crew Chart



NOTE 1: NOMINAL SEPARATION SEQUENCE IS DISCUSSED IN SECTION 4 OF THE TEXT.
NOTE 2: GDC BACKUP ALIGNMENT PROCEDURE IS DEFINED IN THE CREW CHECKLIST

Figure 11. 10-Minute Abort Flow Chart

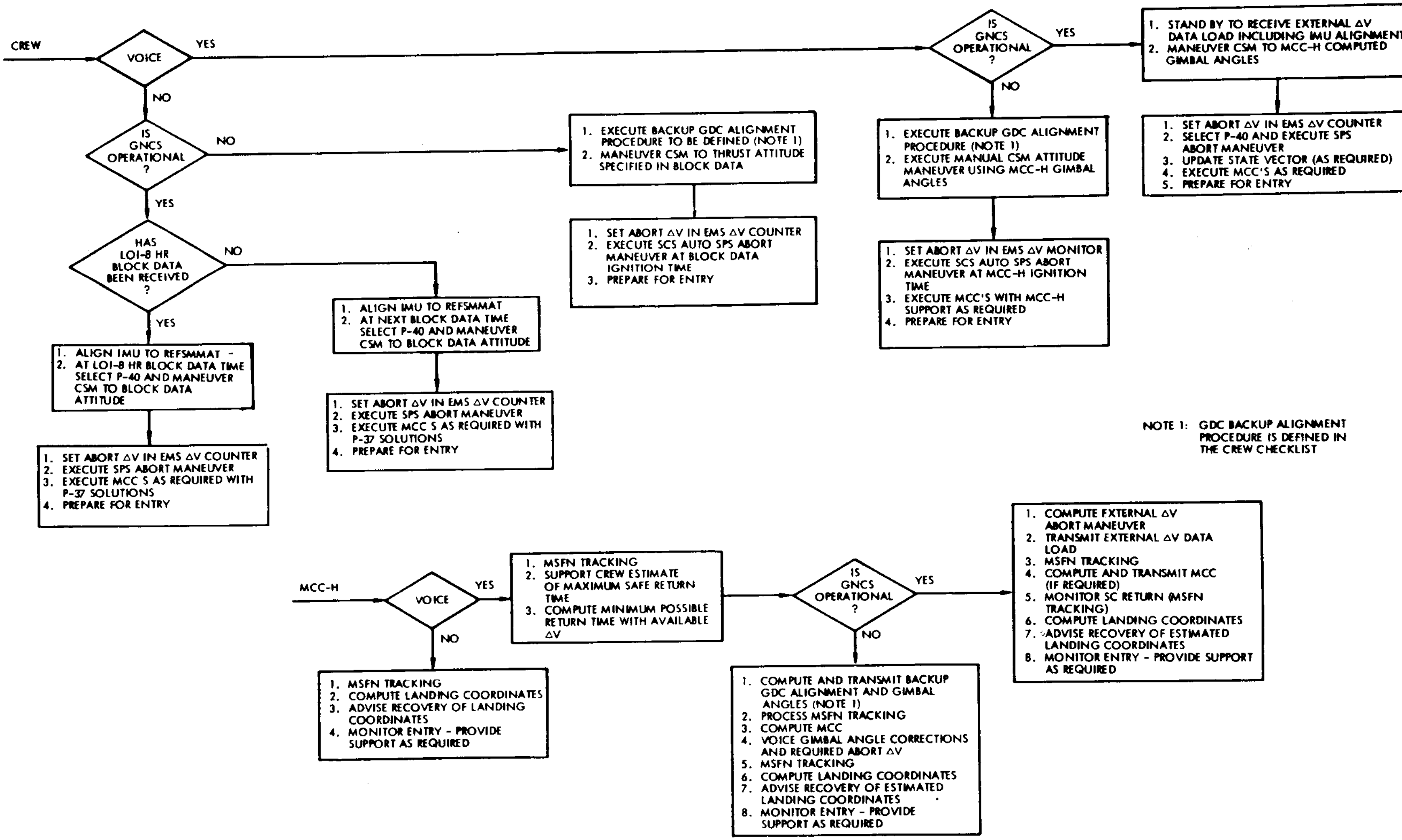


Figure 12. TLC Abort Flow Chart

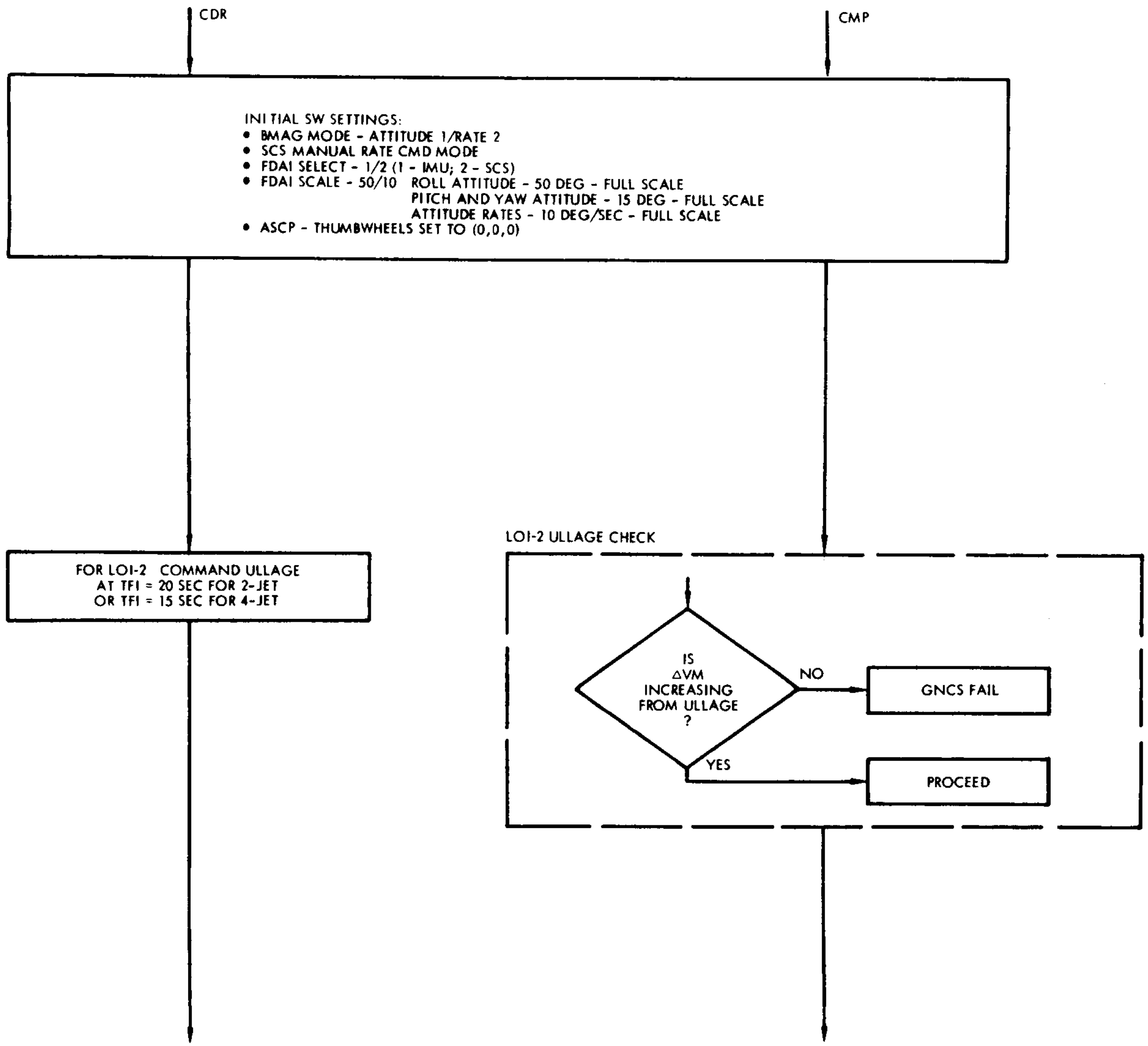


Figure 13. SPS Burn Monitor Flow Chart

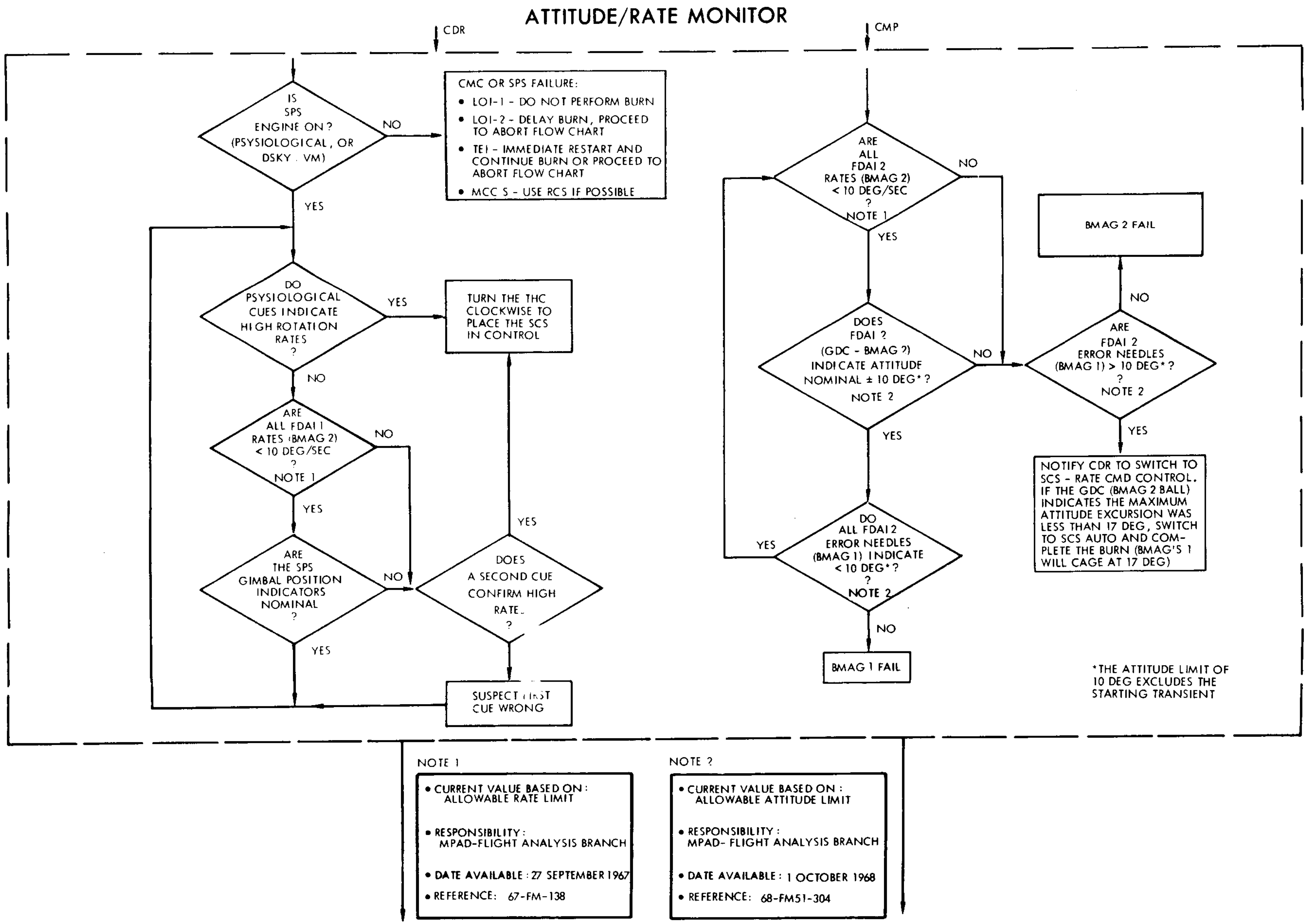


Figure 13. SPS Burn Monitor Flow Chart (Continued)

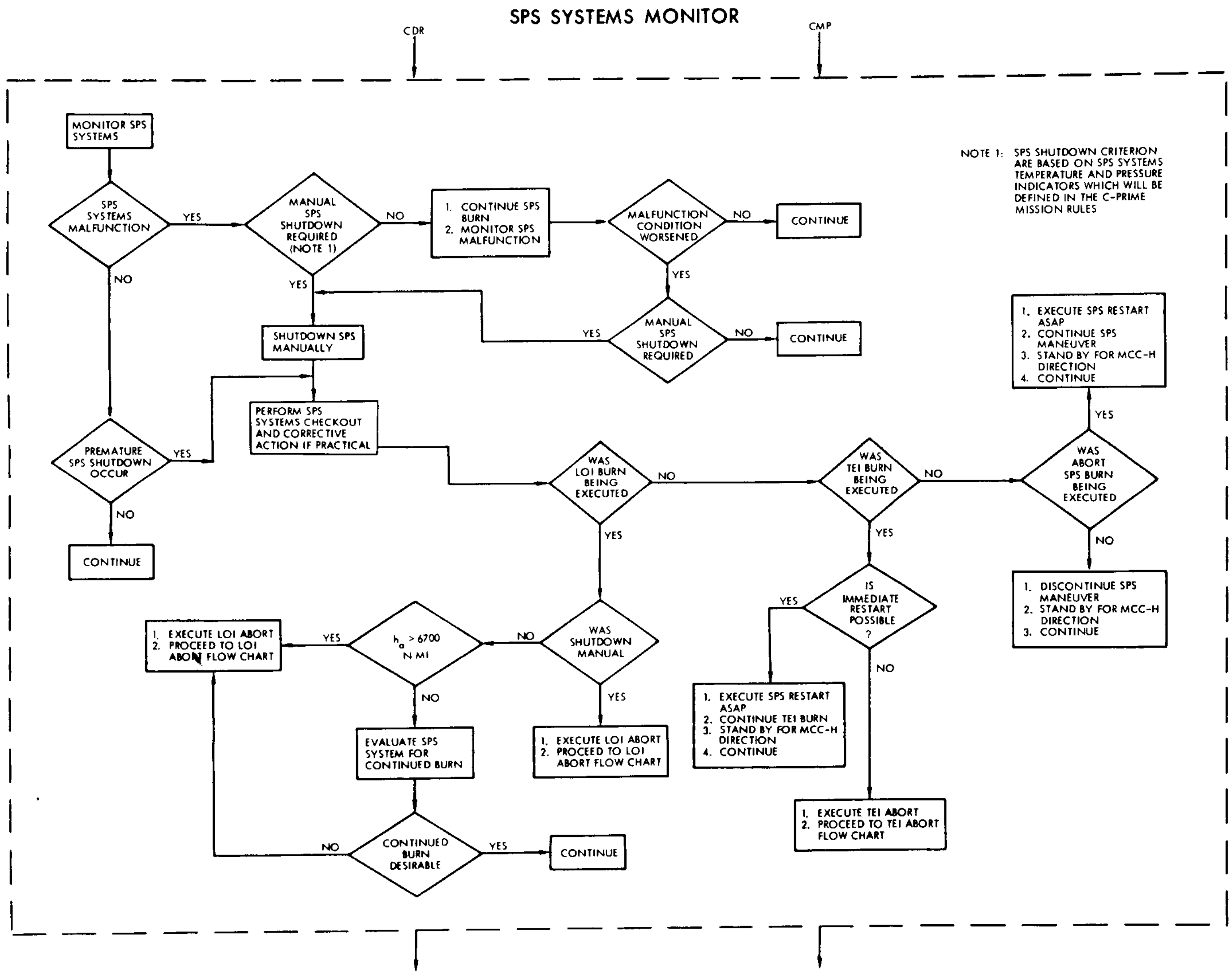


Figure 13. SPS Burn Monitor Flow Chart (Continued)

SPS SHUTDOWN MONITOR

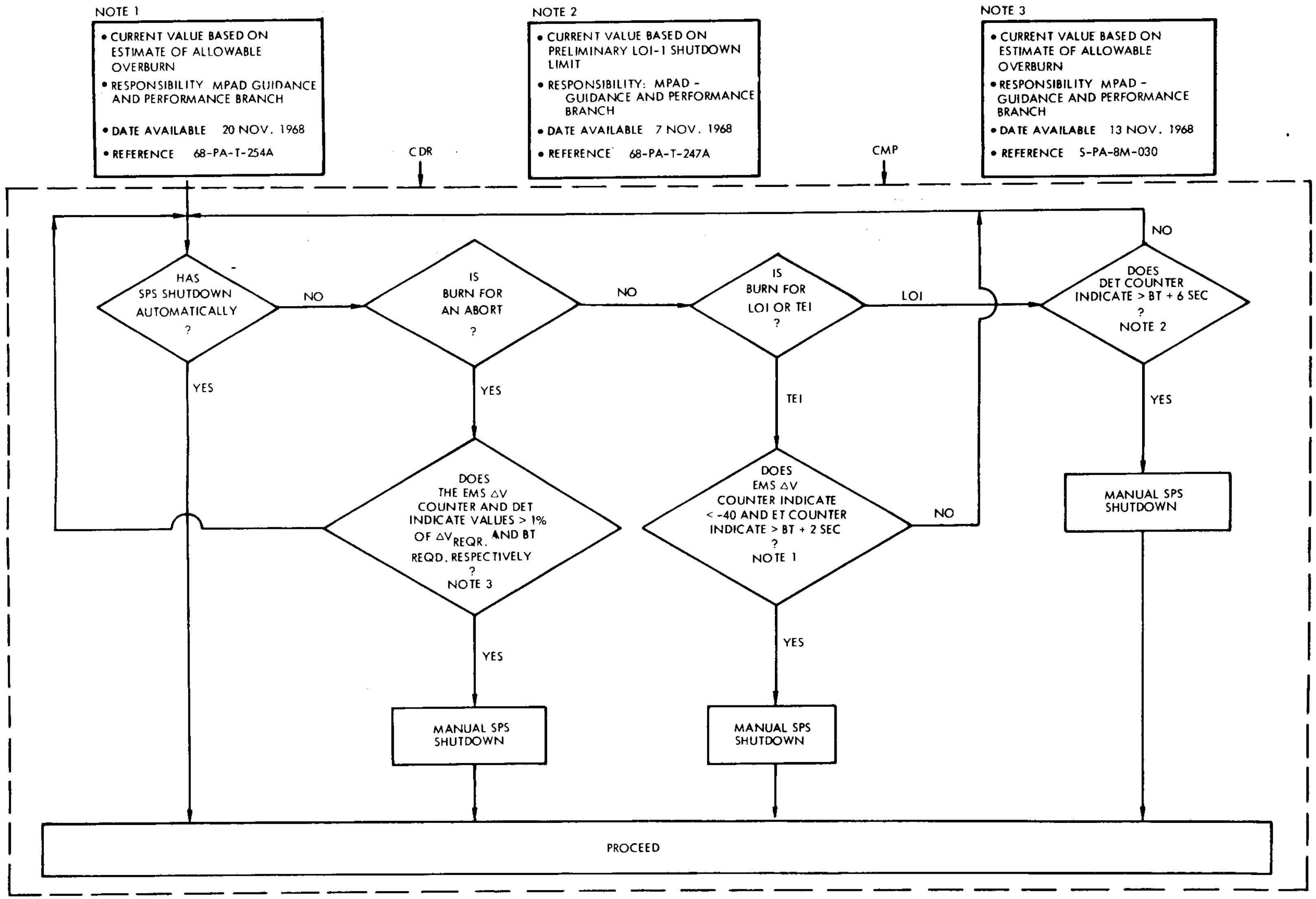


Figure 13. SPS Burn Monitor Flow Chart (Continued)

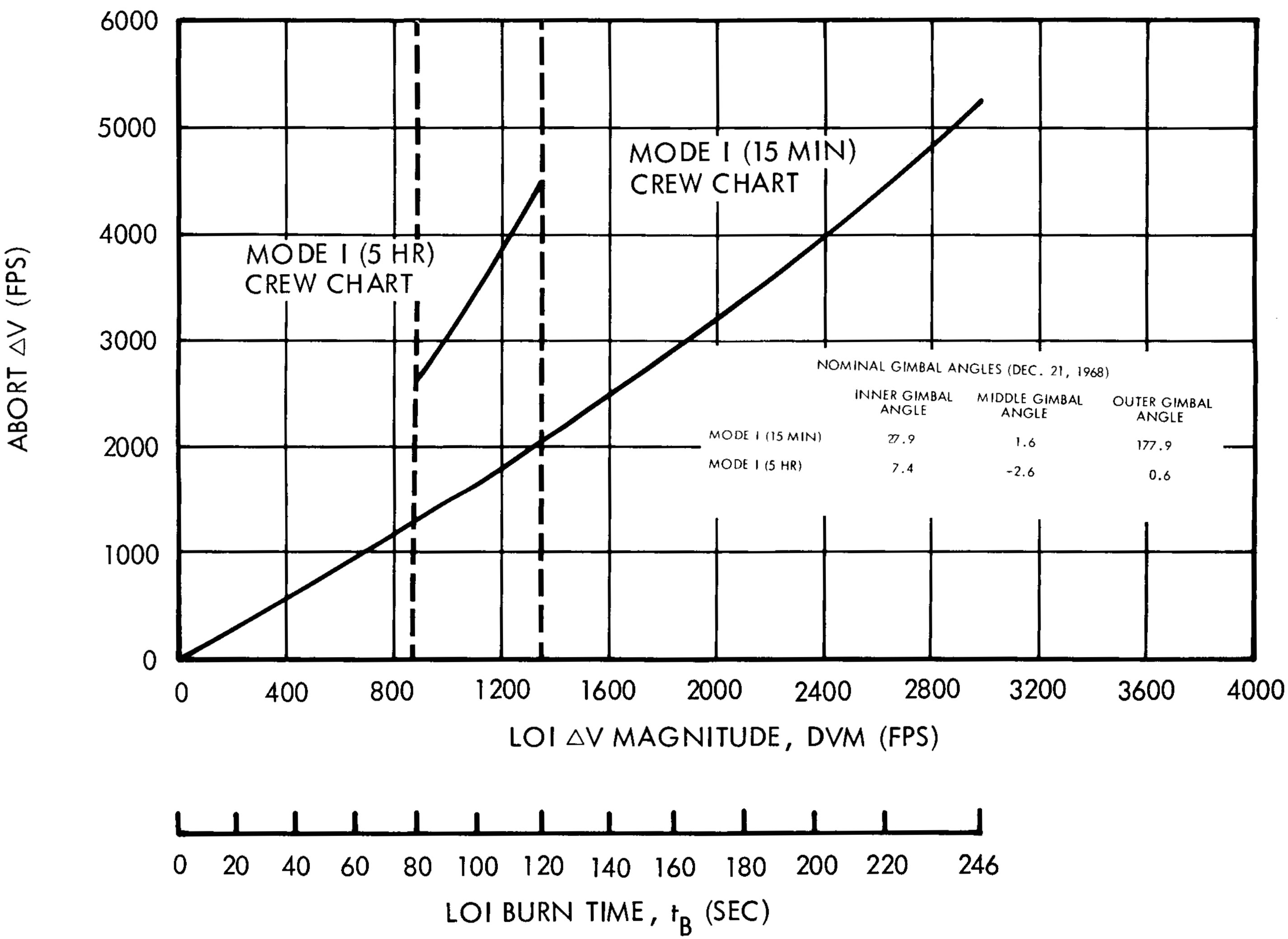


Figure 14. Mode I LOI Abort ΔV Crew Chart

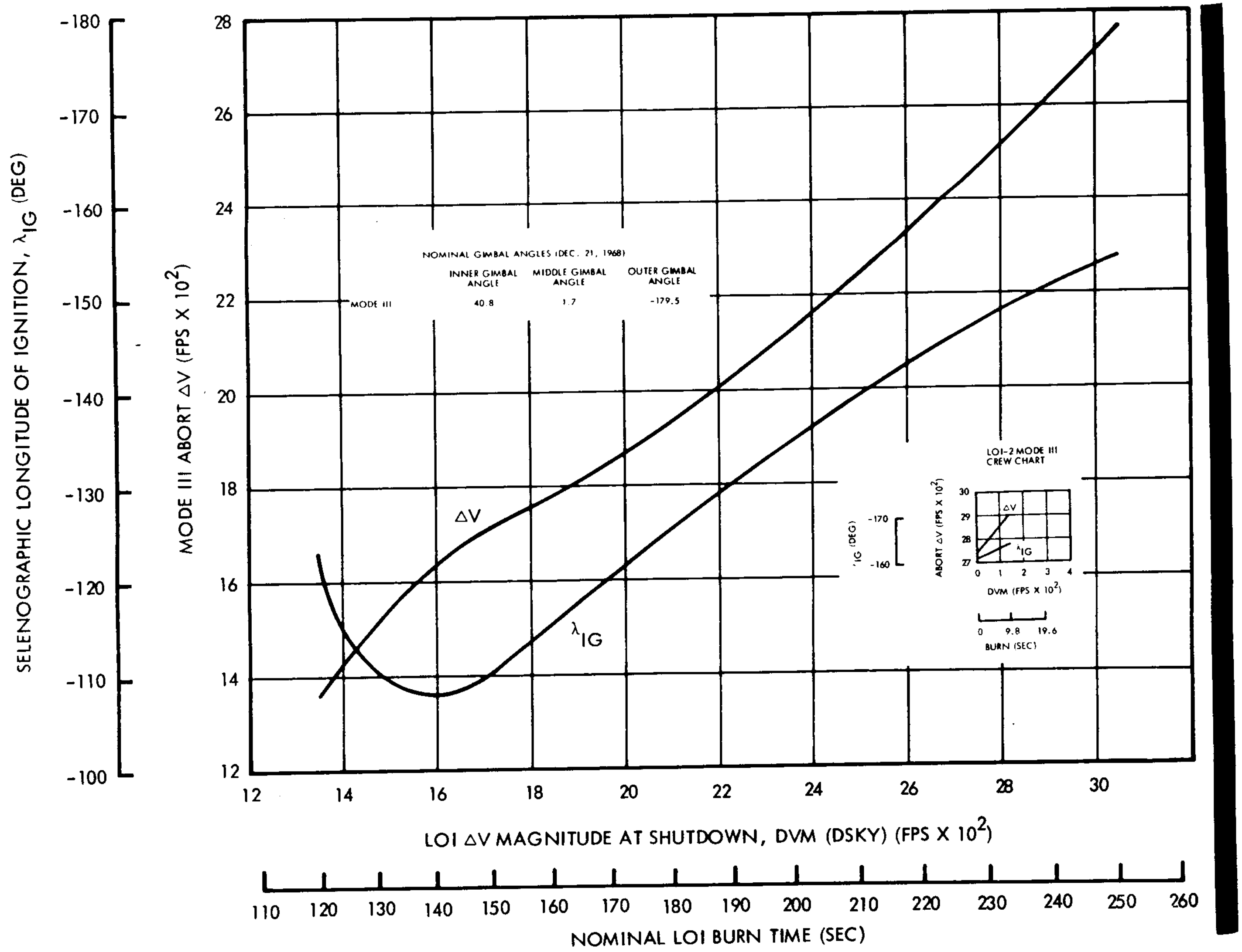
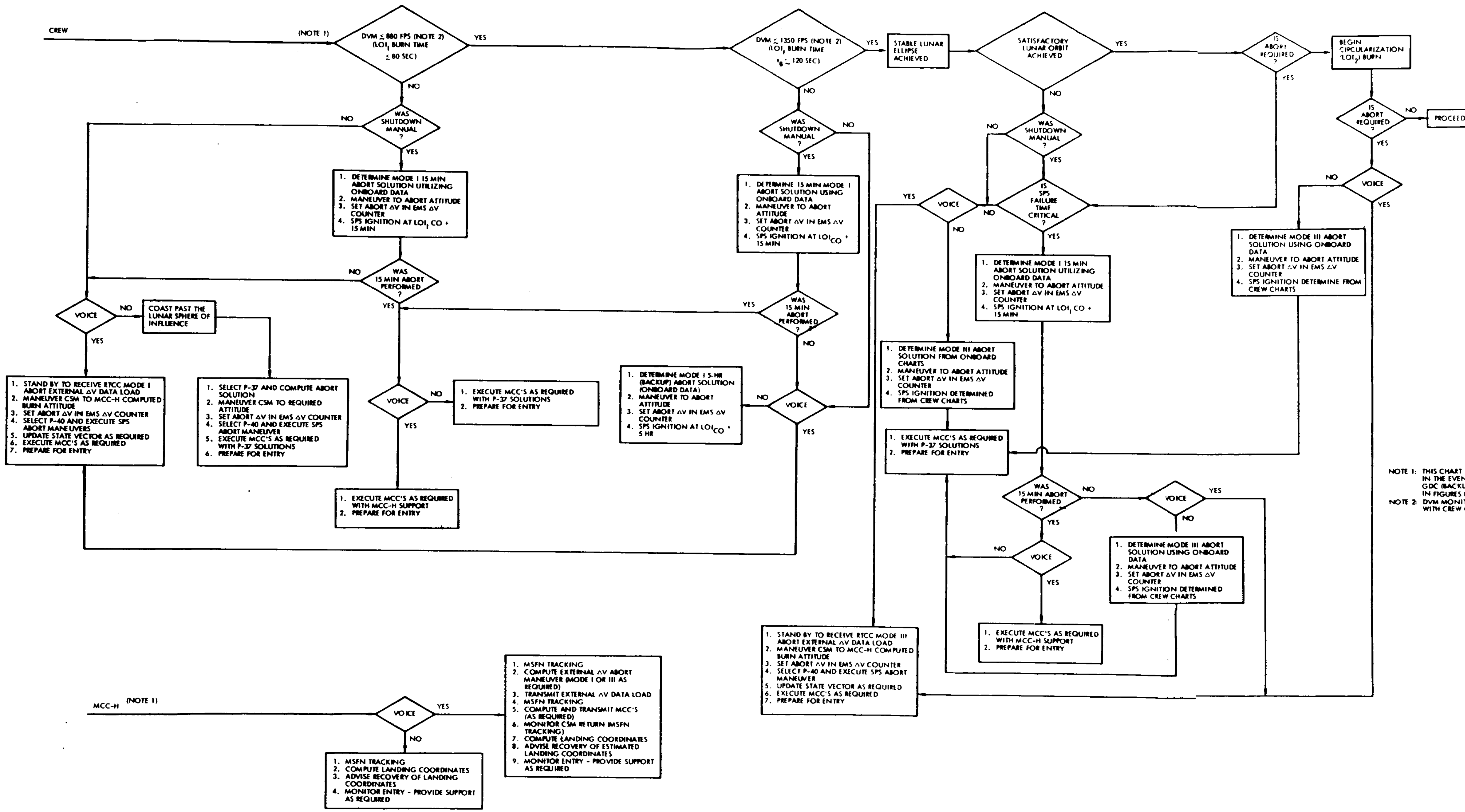


Figure 15. Mode III LOI Abort ΔV Crew Chart



NOTE 1: THIS CHART ASSUMES GNCS OPERATIONAL. IN THE EVENT OF GNCS FAILURE USE THE GDC (BACKUP) ALIGNMENT PROCEDURE IN FIGURES 8, 11, AND 12.
NOTE 2: DVM MONITORED FROM DSKY AND USED WITH CREW CHARTS (FIGURES 14 AND 15)

Figure 16. LOI Abort Flow Chart

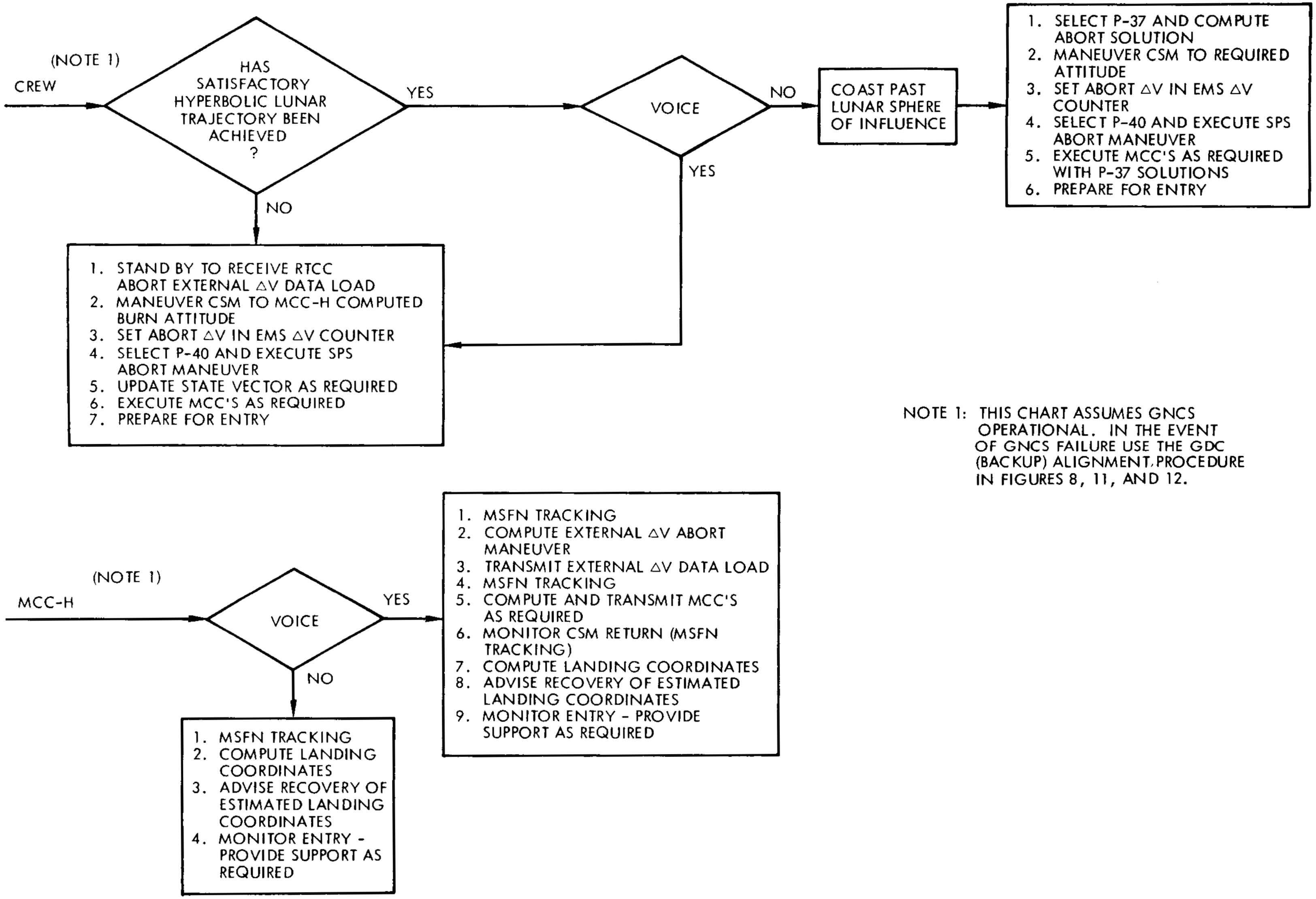


Figure 17. TEI Abort Flow Chart

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11. "Apollo Missions Techniques, Apollo Earth Parking Orbit Retrofire and Entry Procedures (Missions C-Prime, D, F, and G)," MSC Internal Note, 16 December 1968.

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